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WASTES — IN PRODUCTION

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GLASS FORMATION IN BATCH WITH CEMENT PLANT WASTE ADDITIVES

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The possibility and prospects for using cement plant wastes (electric filter dust) in glass melting was evaluated. It was shown that addition of 5 to 15% dust to the batch allows totally excluding sodium sulfate and chalk from the batch. Increasing the content of finely disperse dust in the batch enhances sintering and favors an increase in the specific surface area of the batch and strength of pelleted samples. At a fixed processing temperature, the weight loss decreases with an increase in the dust content.

Key words: cement plant dust, glass batch, enhancement of glass formation.

The evolution of any production sector continuously involves an increasing amount of wastes, expansion of the areas of industrial dumps, and worsening of the environmental situation. The urgency of the problem of utilizing these wastes uniformly increases proportionally.

For example, in firing clinker in rotary furnaces, most of the fired material is carried out of the furnace together with the stack gases. The amount of entrained material is a function of the properties of the raw material, type of furnace, and furnace operating conditions, and constitutes 3 – 20%[4] of the raw mixture consumed.

The cement plant dust (CD) trapped by filters is usually returned to the manufacturing process, but this solution should be considered a forced measure, since the high alkaline oxide content can worsen firing of clinker and the quality of the final product — cement.

For this reason, the search for areas of application of CD in other plants is pressing: for example, it is being successfully used to manufacture local binder materials, silicate items, asphalt solutions, as additives to batch in production of mineral wool, and as mineral fertilizer in agriculture [1].

CD is of interest in glass making due to its chemical composition and high dispersion.

We investigated glass formation in glass batch containing dust with respect to increasing it in comparison to traditional dispersion materials.

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[4] Here and below, mass content.

The following composition of heat-resistant glass was selected for the study, and the mass content of oxides in the glass, %, was: 72.5 SiO_2; 1.5 Al_2O_3; 10.4 (CaO + MgO); 15 (Na_2O + K_2O); 0.6 Fe_2O_3.

Traditional raw materials and cement plant dust were used to make the batch (Table 1). The dust content in the batches was successively varied from 5 to 15%.

In view of the high content of SO_3 (1.72%) and calcium oxide (48%) in the dust, sodium sulfate and chalk were not added to batches containing CD.

To study the intensity of decomposition, the pellets molded from the batches were treated with heat in a muffle furnace at 400 – 1000°C for 1 h. The external appearance of the pellets is shown in Table 2.

Almost no changes were observed visually at temperatures of 400 – 700°C. In the 800 – 900°C range, the pellets made from batch with CD acquired a light blue hue, which could be due to coloring of the glass phase by iron and enhancement of the color due to a successive increase in the content of Fe_2O_3 in the batches from 0.361% in the control to 0.665% in the sample with 15% dust. At 1000°C, all of the pellets melted.

Sintering of the pellets became stronger at the same time that the concentration of dust increased, quantitatively manifested by an increase in the destructive force, and the process was evenly intensified with the appearance of the glass phase (Table 3).

Table 4 shows the change in the weight loss of the investigated samples after heat treatment.

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TABLE 1. Chemical Composition of Raw Materials

Material	Deposit, supplier	Mass content, %					
		SiO_2	Al_2O_3	CaO + MgO	Na_2O	Fe_2O_3	SO_3
Quartz sand	Saratovskoe	99.53	0.12	0.09	–	0.022	–
PShK	Vishnevogorsk Mine Concentration Co.	65.00	21.60	0.55	12.45	0.30	–
Calcined soda	Soda Co.	–	–	–	58.26	–	–
Dolomite	Yamskoe	2.39	0.39	50.74	–	0.20	–
Chalk	Belgorodskoe	2.84	0.22	54.36	–	0.08	–
Cement plant dust	Proletarii Factory, Novorossiisk	25.10	3.33	CaO — 48.00 MgO — 0.51	Na_2O — 0.40 K_2O — 1.95	3.03	1.72

TABLE 2. External Appearance of Heat-Treated Pellets

Temperature, °C	Mass content of dust in batch, %			
	0 (control)	5	10	15
400				
500				
600				
700				
800				
900				
1000				

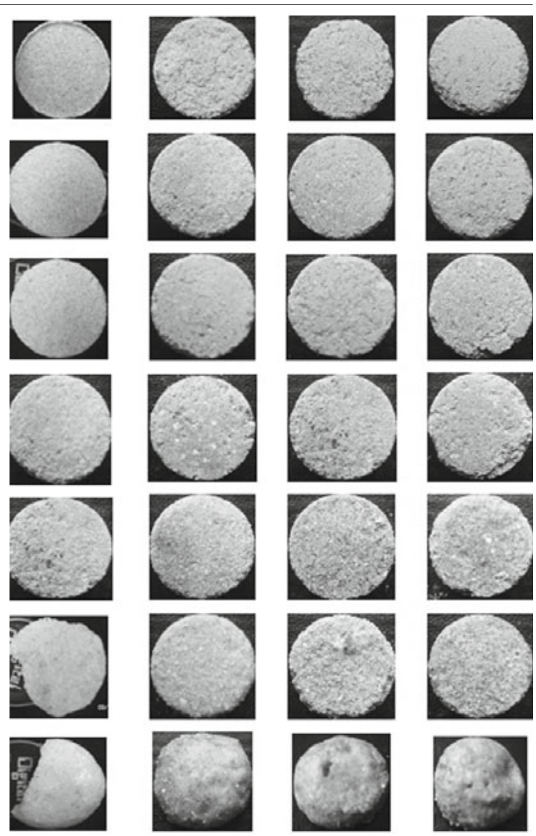

TABLE 3. Strength of Heat-Treated Pellets

Treatment temperature, °C	Force, kN, of destruction of sample with mass content of dust, %			
	0 (control)	5	10	15
600	0.30	0.25	0.55	0.50
900	0.62	0.75	0.83	1.40

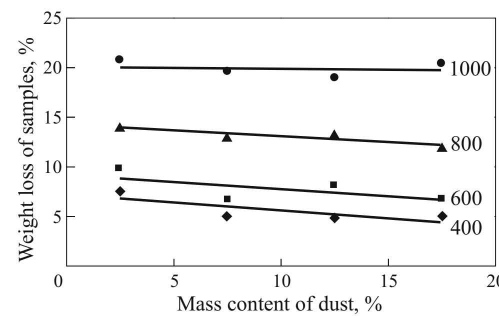

Fig. 1. Temperature changes of relative weight loss of samples $\Delta m_{t,\,i}$ of batch as a function of cement dust content.

The relative weight loss of the samples was calculated with the following equation using the change in the weight of the samples at fixed temperature t

$$\Delta m_{t,\,i} = \frac{m_1 - m_2}{m_1} \times 100\%,$$

where m_1 and m_2 are the mass of the ith sample before and after heat treatment, g.

A graph was plotted with the results of the calculations (Fig. 1), and it shows that increasing the treatment temperature regularly increased the values of $\Delta m_{t,\,i}$ of samples of concrete composition. At a fixed temperature, the increase in the concentration of dust in the samples was accompanied by a decrease in the weight loss of the pellets. In our opinion, this is caused by the fact that chalk, which almost 100% consists of $CaCO_3$, is totally replaced by CD in which calcium oxide is probably represented not only by carbonate but also silicates that are stable when heated.

The degree of the change in the weight loss was evaluated with an arbitrary coefficient

$$K = \frac{\Delta m_{t,\,i}}{\Delta m_{400,\,i}},$$

where $\Delta m_{t,\,i}$ and $\Delta m_{400,\,i}$ are the relative weight loss of the samples at the ith temperature and at 400°C.

TABLE 4. Effect of the Type of Batch on Weight Loss in Heat Treatment

Temperature, °C	Change in the weight of the samples containing cement dust in heat treatment											
	Initial			5% dust			10% dust			15% dust		
	m_1, g	m_2, g	$\Delta m_{t,i}$, %	m_1, g	m_2, g	$\Delta m_{t,i}$, %	m_1, g	m_2, g	$\Delta m_{t,i}$, %	m_1, g	m_2, g	$\Delta m_{t,i}$, %
400	6.6	6.1	7.9	5.9	5.6	5.1	6.3	6.0	4.8	7.9	7.5	5.1
500	7.0	6.4	8.6	6.2	5.9	4.8	6.1	5.7	6.6	6.3	5.9	6.3
600	7.2	6.5	9.7	6.0	5.6	6.7	6.2	5.7	8.1	5.9	5.5	6.8
700	7.2	6.4	11.1	6.0	5.3	11.7	5.9	5.2	11.9	6.4	5.8	9.4
800	7.1	6.1	14.1	6.9	6.0	13.0	6.0	5.2	13.3	6.7	5.9	11.9
900	7.1	5.7	19.7	6.8	5.7	16.2	6.3	5.1	19.0	6.4	5.2	18.8
1000	6.8	5.4	20.6	6.1	4.9	19.7	5.8	4.7	19.0	5.9	4.7	20.3

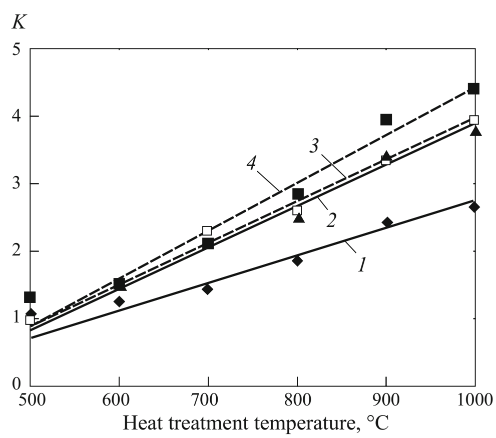

Fig. 2. Degree of the change in the weight loss of samples *K* with a different CD content as a function of the heat treatment temperature. The losses at 400°C were set at 1: *1*) without CD; *2*) 5% CD; *3*) 10% CD; *4*) 15% CD.

As Fig. 2 shows, the value of *K* successively increased in going from the control sample to the batch containing 15% dust.

The change toward a decrease in the granulometry of the batch caused by addition of finely disperse dust is one of the most probable causes of this phenomenon. Actually, the specific surface area successively increased from 1163 for the control to 1314 cm^2/g for the sample with 15% dust (Table 5).

The surface energy of a powder is proportional to its dispersion and has a significant effect on the activity of the material in chemical reactions. In particular, potentiation of the process and a 100 – 200°C decrease in the melting temperature of glass from a batch ground to 100 – 150 and 5 μm fractions is reported in [2, 3]. For this reason, use of finely disperse, chemically active cement plant dust is undoubtedly one of the most probable causes of enhancement of sintering and strengthening of the pellets, as well as acceleration of decomposition of the components of the batch.

TABLE 5. Specific Surface Area of Materials

Index	Dust	Batch with mass dust content, %			
		0	5	10	15
Specific surface area, cm^2/g	6211	1163	1198	1203	1314

The use of cement plant wastes, dust in particular, captured by electric filters, in glass production thus allows totally excluding calcium carbonate, added chalk or limestone, and sodium sulfate from the batch composition.

Sintering and the strength of the pelleted samples are intensified with an increase in the concentration of dust. At a fixed heat treatment temperature, the weight decreases with an increase in the cement dust content in the batch. The effects found are explained by the change in the disperse composition of the batches.

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